

Edible insects: methodology

3.1 Literature review

A literature review was performed in order to identify the available evidence in the scientific literature since the report was produced by EFSA in 2015. The review was carried out with a systematic approach to ensure an objective selection process of the existing evidence. The retrieval and summarisation of results was carried out through a flexible, narrative approach, given the wide variability of topics and study designs predicted to be encountered through the search.

3.2 Research questions

The research questions that this review sought to answer, as written by risk managers, and agreed upon by risk assessors at the FSA, are:

- what are the hazards to human health from consumption of edible insects or their products based on the insects' natural microbial flora and microbiological contamination potential?
- what is the risk of negatively contributing to antibiotic resistance by rearing insects in a farm environment?
- what is the risk to human health from consumption of insects or their products based on their potential to produce or accumulate toxic chemicals in the rearing and production processes?
- what are the allergenicity risks to human health from consumption of the selected insect species or their products?
- what is the risk to human nutrition from consumption of insects or their products?
- what new evidence is available from 2015 to 2019 regarding safety of consumption of edible insects?

3.3 Objectives

The main objectives of the review are:

- to identify new hazards associated with human consumption of insects and insect products relating to the questions stated above, since 2015.
- to identify knowledge gaps related to these areas.

3.4 Search protocol

A systematic search protocol was designed for the retrieval of relevant papers. The protocol includes information on the databases and search terms used, the selection criteria for papers and the type of information retrieved, as well as a description of how this information would be compiled and presented.

While the protocol aimed to provide a systematic structure to the search, the review is not strictly a systematic review and therefore does not necessarily abide by all the relevant rules and principles.

3.5 Databases

Three databases were selected to perform the search:

- PubMed
- Food Science Source
- Web of Science

These were selected based on the nature of the articles expected to be found in them. PubMed provides a source of biomedical scientific articles and acts as a generalist database for the search. Food Science

Source specialises in scientific articles relating to food safety, and acts as the specialist database for the search. Web of Science was chosen following common use by EFSA in literature review searches for food safety related literature reviews.

Other databases were considered but discarded:

- PMC
- ScienceDirect

PMC was discarded due to the high number of non-relevant results obtained in the search when using the chosen Boolean operators, given the low retrieval specificity that this database has. ScienceDirect was discarded as the search tool would not allow for the extensive Boolean term combination to be used.

3.6 Search terms

The first pool of search terms was selected based on the insect species selected to be the subject of this risk profile, and both the scientific and common names were used. The word “insect” was not used due to the lack of specificity of results obtained. The species were selected based on those present in the EFSA risk profile of 2015, as well as those identified by the ACNFP in a past horizon scanning exercise, as the most likely species to be commercially produced for human consumption:

- *Musca domestica* – Common
- house fly *Hermetia illucens*
- Black soldier fly *Tenebrio*
- *molitor* – Mealworm *Zophobas*
- *atratus* – Giant mealworm
- *Alphitobius diaperinus* – Lesser
- mealworm *Galleria mellonella*
- Greater wax moth *Bombyx mori*
- Silkworm
- *Acheta domesticus* – House cricket
- *Grylodes sigillatus* – Banded cricket
- *Locusta migratoria migratorioides* – African
- migratory locust *Schistocerca americana*
- American grasshopper *Schistocerca gregaria*
- Desert locust
- *Mesobuthus martensii* – Chinese yellow scorpion (included despite not being an ‘insect’ per se)
- *Atta laevigata* – Leaf cutter ant
- *Gonimbrasia belina* – Mopane moth

Other terms were identified as they related to human consumption practices and potential risks of this consumption. The terms were distributed into three pools and combined to produce a broad search while maintaining an acceptable level of specificity.

Table of terms

Species	Food	Risk
<i>Musca domestica</i>	Food	Bacter*
<i>Hermetia illucens</i>	Consumption	Allerg*
<i>Tenebrio molitor</i>	Edible	Microbiol*
<i>Zophobas atratus</i>	Market	Substrate
<i>Alphitobius diaperinus</i>	Process*	Vir*
<i>Galleria mellonella</i>	Roast	Accumulat*
<i>Achroia grisella</i>	Human*	Contamin*
<i>Bombyx mori</i>	Boil	Chemical
<i>Acheta domesticus</i>	Eat*	Parasit*
<i>Gryllodes sigillatus</i>	Entomophag*	Toxi*
<i>Locusta migratoria migratorioides</i>	Ate	Antibiotic*
<i>Schistocerca americana</i>	-	Risk
<i>Mesobuthus martensii</i>	-	Safety
<i>Atta laevigata</i>	-	Hazard
<i>Gonimbrasia belina</i>	-	Intake
<i>Schistocerca gregaria</i>	-	Expos*

Species	Food	Risk
Common house fly	-	-
Black soldier fly	-	-
Mealworm	-	-
Giant mealworm	-	-
Lesser mealworm	-	-
Greater wax moth	-	-
Lesser wax moth	-	-
Silkworm	-	-
House cricket	-	-
Banded cricket	-	-
African migratory locust	-	-
American grasshopper	-	-
Chinese yellow scorpion	-	-
Leaf cutter ants	-	-
Mopani moth	-	-
Desert locust	-	-

Boolean search

((musca domestica) OR (hermetia illucens) OR (tenebrio molitor) OR (zophobas atratus) OR (alphitobius diaperinus) OR (galleria mellonella) OR (achroia grisella) OR (bombyx mori) OR (acheta domesticus) OR (grylodes sigillatus) OR (locusta migratoria migratorioides) OR (Schistocerca americana) OR (mesobuthus martensii) OR (atta laevigata) OR (gonimbrasia belina) OR (schistocerca gregaria) OR (common house fly) OR (black soldier fly) OR (mealworm))

OR (giant mealworm) OR (lesser mealworm) OR (greater wax moth) OR (lesser wax moth) OR (silkworm) OR (house cricket) OR (banded cricket) OR (African migratory locust) OR (American grasshopper) OR (Chinese yellow scorpion) OR (leaf cutter ants) OR (mopane moth) OR (desert locust)) AND ((food) OR (edible) OR (process*) OR (market) OR (human*) OR (consum*) OR (roast*) OR (boil*) OR (eat*) OR (entomophag*) OR (ate)) AND ((risk) OR (allerg*) OR (toxi*) OR (safety) OR (microbiol*) OR (hazard*) OR (substrate) OR (parasite*) OR (chemical) OR (accumulat*) OR (contamin*) OR (antibiotic) OR (bacter*) OR (vir*) OR (intake) OR (expos*))

The search was capped to show articles published between January 2015 and November 2019

3.7 Selection criteria

This section of the protocol served as a guide to researchers rather than a set of rules. Adherence to these guidelines was kept flexible to allow for the inclusion of articles that could provide valuable information.

Articles obtained through the search were screened for relevance in two different stages:

In the first stage, all titles and abstracts obtained were sifted on three different criteria:

- the article mentions a relevant insect species or insects in general.
- the article mentions a food-related or human safety component.
- the article was published in English or Spanish language.

The articles included after the screening in stage 1 were obtained and read for further selection:

In the second stage, the selected articles were read and kept for analysis and inclusion in the review as long as they presented information that could be relevant to evaluate the risk of human consumption of edible insects.

3.8 Extraction form

No formal extraction form was used in the production of this review, as the lack of specificity of the research questions found that such forms were not useful. However, a series of common themes of information were sought out, including:

Insects

- species
- stage of development
- rearing characteristics
- substrate
- place of rearing

Consumption

- alive/dead
- raw/cooked
- whole/pulverised
- processed/processing type
- quantity/daily intake

Risks

- allergenicity

- viral/bacterial/parasitological infection potential
- toxic compounds
- AMR bacteria

Not all the information extracted was reported in the review's narrative synthesis. A summary of some of the data retrieved can be found distributed in tables in the Appendices section.

3.9 Synthesis

Due to the lack of typified information that was obtained through the inclusion of different types of study, as well as time constraints for the production of the review, synthesis was performed narratively, grouping studies of the same type where appropriate.

3.10 Results

After entering the search terms, PubMed retrieved 1431 articles, of which 91 were selected in the first sift. Food Science Source retrieved 312 articles, of which 16 were selected in the first sift. Web of Science retrieved 25 articles, with only one being selected after the first sift. Of the total 108 articles selected, 10 were discarded for duplication, for a final 98 articles to be analysed individually.

After analysis, 39 articles were discarded for lack of relevant data, and a further 17 were added retrieved from reviews identified in the systematic process or to complement the information presented. These additional articles did not appear in the search terms for not being present in the selected databases or for being published outside of the 2015-2019 selected period of time.

The following sections of the report summarise the results from the analysis of all obtained studies. Only those results claimed to be significant by the authors were reported. It is structured with the scientific evidence retrieved first, followed by the identified risks and the potential control measures as derived from the literature.